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SOME MEDICAL PROBLEMS OF AUSTRALIA

Three Papers read in opening Discussions at the Annual Meeting of the British Medical Association, Melbourne, 1935

Problems of Racial Pressure in the Pacific:

By Sir RAPHAEL CILENTO, M.D., Director-General of Health and Medical Services for the State of Queensland.

Australian Aerial Medical Services:

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Weil's Disease in North Queensland:

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SOME PROBLEMS OF RACIAL PRESSURE IN THE PACIFIC*

BY

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Assuming that the objective of the opener of a debate is to provoke discussion, I suggest three propositions mutually dependent: (1) Every previous culture has had its period of growth, vigour, and dominance ; its period of arrest, stalemate, and disillusion ; and its decline and fall. (2) Populations, as Malthus said in 1798, always tend to increase up to the limits of available subsistence, and, indeed, would inevitably do so were they not subject to the positive checks of war, disease, vice, and misery, and also to the prudential check† of deliberate limitation. (3) In animals, plants, and also in societies evolution is both progressive and retrogressive constantly, and the specialization to a particular environment which is a notable factor for advancement becomes a fatal weakness when the environment is changed.

The Fate of Cultures

When in the Jackson Lecture of 1933[1] I made some reference to the growth, flowering, and decay of civilizations I had not had the privilege of studying the remarkable works of Oswald Spengler.[2] His personal contribution to a well-worn story is the demonstration that not only have the histories of all cultures a general similarity, but the course of each conforms so closely to one standard as to make all essentially identical. He takes the ground, therefore, that from ancient facts present tendencies can, in the gross, be forecast.

It is accepted by chemists, I am told, that what were thought to be the ultimate elementary substances are themselves infinitely complex, and that myriads of particles, individually discrete and different, go to make up each recognized atom. In spite of so varied a constitution, these atoms react meticulously to known laws. Spengler, it would seem, adding time to the series, claims that " all that is cosmic bears the hallmark of periodicity," and, though man himself, he says, is additionally " a microcosm in relation to a macrocosm," it is not difficult to read into his view the idea that a culture, however individually discrete and varying its myriads of human particles, inevitably reacts as one entity to large-scale (meteorological?) influences operating at regulated intervals.

But the student of Spengler will be struck by the fact that from first to last, neither in his text nor in his index, does he mention disease or famine in the fate of cultures. The only sickness he knows is sickness of the soul, the only virility, virility of the spirit. He seeks no physical stimulus in that " first stirring " towards progress in the basic barbarian mass ; and for the fact that the life blood of every culture pours away in an enormous decline of population he scouts any scientific explanation: he postulates as sufficient a metaphysical " turning towards death," seen only at the end of a culture and in city populations. Nothing could be further from the truth. W. H. R. Rivers and several of his collaborators, in their *Essays on Depopulation* (1922), found precisely the same manifestations of decline, not among city dwellers, but among the primitive savages of Oceania in their island atolls and forests. For want of a better explanation, or perhaps from a similar metaphysical leaning, they, too, ascribed it to psychological causes—a " turning towards death."

In an area where there had been postulated on philosophical lines that " fatal disturbance of cultural equilibrium at the hands of missionary, trader, planter, or official, which has brought about the depopulation of so many islands, and has extinguished so many native cultures in the Pacific,[3] it was found that the depression was secondary to sickness and under-nutrition.[4] Population among these native races is found declining in places where native institutions flourish with all their original vigour, as well as where they have been destroyed ; and the people are found thriving in places where white men have entirely disrupted their social organization, as they must inevitably disrupt it everywhere in the course of time.

The factors operating adequately for decline were: (1) introduced diseases, such as malaria, hookworm, and tuberculosis ; (2) faulty sanitation of environment ; (3) privation and poverty of diet ; and (4) abortion and infanticide. Malaria and such chronic diseases were producing lethargy and bodily weariness which prevented anything but the most essential tilling of the soil or foraging for food, while the very poverty of the diet that resulted lowered the resistance to disease and so permitted more frequent disease, with constantly lessened food supplies, until a point had been reached at which the human organism could no longer cope successfully with the situation. In the most sophisticated city and in the most primitive jungle, therefore, one sees identical results so long as disease and indigence plough the body and sow despair.

Depopulation with Decline of a Culture

No one will deny the depopulation and the disillusion that accompany the decline of a great culture. In ancient Egypt, for example, after the social revolution of the Third Millennium B.C., population fell rapidly. The history of Mesopotamian culture furnishes many examples. In the Augustan Age of China, in the third century B.C., all sorts of measures were used to promote population. Polybius deplored race suicide as the ruin of ancient Greece, where not only was it common for several centuries following the most brilliant period, but expediency decreed that marriage and childbirth should become contemptible among the aristocratic, and unnatural practices fashionable even among the highly intelligent. In Augustan Rome, race suicide became appallingly common, and there appeared again a reaction against child-bearing as plebeian and degrading. The Augustan Age of Rome produced,[5] indeed, almost desperate marriage-and-children laws. But what availed when the flow to the city was so great that its unemployed were numbered in hundreds of thousands, and when whole provinces fell out of cultivation for lack of labourers? In A.D. 193 Pertinax published his famous edict by which anyone in Italy or the provinces was permitted to possess himself of vacant land and to acquire its legal title if he restored it to cultivation. It was all useless, for it was " an advantage to be childless."

In our own civilization, we already see, it is true, a similar tendency. As Spengler describes it, the primary instinct and vocation of woman from her childhood is motherhood. But " the Ibsen woman " of the city Colossus feels, as Bernard Shaw states, that " unless she repudiates her womanliness, her duty to her husband, to her children, to society, to the law, and to everyone but herself, she cannot emancipate herself! " Instead of children she has " soul conflicts " ; the robust family is something about which to be apologetic ; the father of many children is in city life a subject for caricature. At this stage, to quote Spengler, the " whole pyramid " of

* Read in opening a discussion at a meeting of the combined Sections of Public Medicine and Medical Sociology at the Annual Meeting of the British Medical Association, Melbourne, 1935. [Abridged.]

† Malthus only visualized the prudential check as a matter of individual moral restraint, aided by those economic circumstances that tend to postpone the age of marriage.

cultural man vanishes ; it " crumbles from the summit," and at the last only the basic primitive blood—the " fellaheen " type—remains, robbed of its virile and progressive elements.

Throughout all these periods of cultural decline the stigmata of frustration follow their typical course, and find an outlet in apathy or exaltation, whether the victim be a native dreamily chewing betel nut, a Malay *amok*, a city neurasthene, an early Christian of the fifth century welcoming the barbarian sword as a passport to a glorious eternity, or his Egyptian forerunner of 2600 B.C.

Expansion of Western Civilization

But depopulation and disillusion are merely the negative phases of the equally unbalanced ascent and expectancy of the population period ; and these again result from whatever new economic advantage upset the stagnant equilibrium of their former level. Massed labour in the form of droves of slaves it may have been; massed labour in the form of the machine with us.

At the beginning of Queen Anne's reign (1704) the population of England was six millions (less than that of Australia), and only one million lived in the cities ; in Malthus's day (1798) it had reached eleven millions, and the percentage in towns was doubled. Ripley says that of the 105 towns of more than 25,000 people in England sixty have come into being since 1825. The birth rate increased somewhat in that eighteenth century, remained roughly stationary until about 1876, when economic pressure made prudential limitation advantageous, and has declined persistently since. The death rate fluctuated somewhat towards the close of the eighteenth century, and then declined markedly as the fortunes of England rose with the Napoleonic wars. This decline was handicapped and temporarily arrested about the middle of the nineteenth century (partly by epidemic disorders), and then resumed its descending course. It follows that the great increase in population in this age of urbanization was due largely to a decline in the death rate, and those favourable factors in environment that brought it about.

The world of the nineteenth century was a world open to the exploiter: expansion was possible into many partly occupied territories, and potential markets lay on every side ; a tremendous impetus was given to the Western peoples. In the Pacific it produced, *inter alia*, three " moonlight " civilizations, as Spengler calls them, civilizations that take their light from a live source, and may even re-radiate it in a permanent form. They were the United States of America, Australia, and Japan.

The United States, in the full flood of that tide, grew at a rate that will astound posterity, and has come to be the extreme exponent of the megalopolitan civilization of to-day. Its initial rise gave place early to an independent expansion. The impetus that gave it birth had almost exhausted itself before the colonization of Australia was called for ; and the population of Great Britain had reached its maximum before Australia was a century old, and before it had done more than fringe the subtropical coasts with settlements. Japan, originally a " moonlight " offshoot of the Han civilization of China (A.D. 220), definitely attached itself to the new light of Western civilization in 1868, and will stand and fall with it. A Japanese culture *per se* there never has been except in an imitative sense, and the present Japanese Americanization must not be regarded as Oriental on analysis.

In the Pacific itself our culture struck the Oceanic peoples with variable violence. The old civilizations of the Dutch East Indies, with peace and increased productivity, responded by an increase of population from eight millions in 1816 in Java to thirty-seven millions a century later ; the specialized primitives of the Oceanic islands, on the other hand, lost 75 per cent. of their population in two generations.

Limit of Employment the Malthusian Limit of Subsistence

In Europe the doctrine of Malthus[6] that population tends to outrun subsistence was more and more doubted as the harnessed science of the industrial era produced food in quantities never previously contemplated, nor was the disparity between production and availability adequately apprehended as a matter of practical politics. The increase in the food consumed was obvious in the aggregate, as were the betterment of the standard of living and the higher wages, but it became increasingly difficult to provide employment of a gainful nature. The truth became more apparent daily: the population a country can support is the population it can provide with gainful employment. Is not this again merely the Malthusian " subsistence "? Nature sets herself to correct any surplus of population by the pressure of direct and indirect checks, but the amplitude of the curve is such that a generation or two must pass before any " Augustan Age " is paid for.

The optimism of the World Congress on Population Problems at Geneva in 1927 was in striking opposition to the feeling of 1931. At the latter, the present wave of economic depression had reversed opinion, and the emphasis was laid not upon the dangers of over-population in western Europe, but upon the prospect of an imminent and appalling depopulation of that source of present-day civilization. Dr. Eugen Fischer, demonstrating the pronounced decrease in the average size of families of certain classes in Germany between 1879 and 1910, remarked despondently: " These few figures clearly indicate the condition of the people—it is that of a moribund community."

Dr. Louis I. Dublin considered it not improbable that the population of the United States of America would reach a maximum of 149,000,000 in 1970 and would then, in the course of the next sixty years, halve itself. Professor Fernand Baudhuin, speaking of the future of France and Belgium, said: " In any case, the people to which we belong will suffer the consequences of the policy they are now putting into practice. They are probably destined to disappear or to be absorbed by newcomers." And he drew a graphic picture of a new invasion by Slav races, first the Poles, then the Russians, in the measure that the Latin countries of western Europe became depopulated. Several speakers gently ridiculed this despondency, pointing out that the elaboration of a simple, reliable, and fool-proof contraceptive, or the outbreak of a new and uncontrollable epidemic disease or a new virulence in old diseases, such as, say, influenza, selecting particular races or localities, or the discovery of an organism capable of converting worthless cellulose into an assimilable foodstuff, or any one of an enormous number of unforeseen circumstances, " might well stultify the prognostications of all existing authorities on population and hopelessly distort their graphs and curves." But these comfortable words are merely hopeful conjecture.

As a matter of fact the rapid fall in the birth rate, the declining proportion of youth, and with it the declining proportion of potential mothers, are all actually correcting the disparity between population, production, and consumption, in all the civilized lands except Italy, Russia, and Japan. It should be the natural and desirable solution, unless it means, as it so frequently has, a new inevitability of conflict with or between these other Powers and a loss of frontiers and culture. The food problem has certainly set the stage for Spengler's " era of contending States."

The Estimated Expansion of Japan

As Dr. Shiroshi Nasu[7] and Dr. Naomasa Yamasaki[8] recently pointed out, the Japanese people were stationary and balanced against subsistence for three hundred years, until the Meiji Restoration of 1868 swept them into the life-stream of Western civilization. Food, wages, standards, all increased most rapidly, families flourished with the new availability of food ; the intensive methods of contraception of the Tokugawa period were legally banned. The result was that the population of Japan *proper* increased in sixty years from twenty-eight millions to sixty millions. It has reached saturation point. Half the population is a peasantry that farms two and a half acres per man ; by the most intense activity the area under cultivation has increased by 36 per cent., the pro-

duction by 48 per cent. But the standard of living, as represented by the consumption of rice per head, has risen by 60 per cent. ; 20 per cent. of that staple crop is now imported, and Japan is realizing to the full both the force of the "law of diminishing returns" and the significance of Karl Marx's dictum that as the technique of production continues to improve, unemployment must inevitably increase and intensify. The urbanization of her people has increased meanwhile from 30 to 50 per cent., while the population has been doubling.

The birth rate is now from 26.06 to 45.24 in various prefectures (34.92 is the mean) ; and the death rate varies similarly from 17.26 to 25.40 (with a mean of 20.27). Both rates have increased during recent years, the former from 24 to 35, the latter very slightly and mainly as a result of milk deficiency. The deaths of infants under 4 years in 1925 reached the total of 381 per 1,000, precisely as in England when the industrial age first swept family life into the factory a century ago. The age constitution of the population is that of England seventy years ago.

There has been some revival of contraception, and for this and other reasons associated with a city environment the birth rate is lowest in the densely packed cities of Kyoto, Osaka, Tokyo, etc. Ellsworth Huntington some years ago[10] set the causes of the heavy death rate down as: (1) unbalanced diet ; (2) the great density of the population ; and (3) the dangerous heat of the summer climate. The last is opposed to experience, for in the worst of the summer climates, that of Kyushiu, the death rate is lowest.

The density of the population, however, is perfectly obvious: it represents four persons to the acre of arable land, and is increasing. Birth control lags always a generation behind the problem it hopes to solve ; emigration would need to reach one million a year to cope with the surplus, and emigration is no corrective. It appears inevitable that, on present figures, Japan *proper* will steadily increase to a figure of 113,239,000* in 1967, at which period England and America will reach their period of stalemate and decline—and with them Australia. This is a situation to be feared both in the interests of these countries and of the world in general.

As to the lack of balance in the diet, its vital significance is the thesis of this paper.

Population Problems of Australia

Here in Australia our "moonlight" civilization mirrors the decline in birth rate and population seen in western Europe most alarmingly, for these things act here not as a safeguard but towards disaster. We cannot preserve our frontiers unless we can effectively occupy the land we claim, and the problem is vast. Certainly we have done well in actual figures.[11] During the period 1911–21 our increase corresponded to 2.01 per cent. per annum, and from 1921 to 1933, in spite of actual loss owing to the depression, it was 1.83 per cent. per annum, the chief increase going to the State of the future: Queensland. But with regard to distribution, Australia is becoming more urbanized without provision in the secondary field. The percentage of population in country districts fell from 37.35 per cent. in 1921 to 35.92 per cent. in 1933, and this is the tendency of several decades.

It is in respect of natural increase that our figures are most disturbing. From 1861 to 1931, 75.92 per cent. of the population was provided by natural increase and 24.08 per cent. by immigration. But during the thirty-two years of recorded figures since 1900 this figure has fallen to 19.23 per cent., and from 1927 the figures for the individual years show a decline which resulted in an actual loss in 1930, 1931, and 1932. (Incidentally, the nominated and selected immigrants fell in number from 30,123 in 1927 to 275 in 1931, and 175 in 1932.)

Our birth rate is now one of the lowest in the world, but fortunately our death rate is phenomenally small, so that we make a reasonably good showing in respect of natural increase ; but as Dublin recently pointed out—the natural increase rate is fallacious. In his experience an American rate of 10.99 per 1,000, when corrected in terms of the biological constitution (age frequency of maternal pregnancy and mortality) becomes no more than 5.47 per 1,000.

This criterion applied to Australian figures by Exley[12] shows several tendencies which are unfavourable. The average age of the population is rising rapidly, and the proportion of youth is declining. The *Year Book* of 1933 shows that young and middle-aged arrivals have fallen from two-thirds to little more than one-half ; the proportion of older people among them has risen from one in seven to one in three ; and in respect of departures from Australia, the depression prompted many people in the age group 15–35 to leave Australia for other lands in search of employment. The best of all immigrants, the baby, formerly represented by 3.34 (1911) per family, has fallen to 2.95 (1932), so that the average issue of mothers has fallen 13.22 per cent., and there are considerably less potential mothers. The natural increase for 1931 was half that of 1891. Exley concluded from his study that, in terms of natural increase, the stable population of Australia, on present figures, would represent no more than 8,500,000, and would contain an excess of females of approximately 35 per 1,000. The solution is immigration—or ultimate invasion.

Specialization to Environment

A reference was earlier made to specialization: it is ambivalent in its implications. Spengler describes as the underlying fact of all cultures the eternal peasant, but the more primitive the peasant the more is he the creature of his environment. Demoor, Massart, and Vandervelde,[13] as the result of their investigations into animals, plants, and human societies, held that all evolution is at once progressive and retrogressive, that all modifications of organs or of institutions are attended by retrogression, but that this universally degenerative process does not retrace the steps of its original advance. They found, further, that degenerative evolution is brought about by a limitation in means of subsistence, and limitation either of nutriment, of capital, or of labour. They added that the occasional causes were inutility of function, insufficiency of nutriment or resources, and (in biology only) lack of space.

The Pacific peoples demonstrate how isolated populations are specialized to their environment. The effect of European intrusion may be divided into three period.[14] First, a period during which the native was attacked by actual arms, by alcohol, by the diseases introduced by the newcomers, by dislocation of tribal life and customs, by recruitment for labour of the young and virile members of the population, and by alienation of the accessible fertile land and the introduction of plant and animal pests. An enormous and immediate decline naturally followed. This period has long since ended in the Pacific. It was sufficiently disastrous, however, to reduce the population by 75 per cent. between 1860 and 1890.

The second period is that of partial adjustment, when the European seeks to impose his scale of values on the native and the native seeks to imitate the European ways of life, both with conspicuous lack of success. It is during this period that the native loses the safeguards of savagery, and fails, either through lack of opportunity or actual incapacity, to substitute for them the protection of European customs in detail. He has been specialized to his environment, and with the sudden introduction of new factors he is taken at a disadvantage. The unstable equilibrium that is produced is most characteristic where populations are under partial control, and is seen in many localized areas in Melanesia, in all of which the population is either oscillating about an uncertain level, or slowly decreasing. So delicate, however, is this condition of partial equilibrium that marked effects may be produced upon it by circumstances which would appear, otherwise, to have only a casual significance.

* The Japanese Empire (as distinct from Japan proper) comprises some 120,000,000 subjects at present.

The third period is that in which the attempted adjustment either fails or succeeds. In the former case—and it is a rare one—the native population disappears, as in Tasmania; in the latter, it begins to progress in a satisfactory manner, as, for example, in Samoa.

Important Causative Factors in Diminished Population

One of the largest factors in the diminution of the native population has been the great mortality that occurs during the first five years of life. Even in Fiji, where there is no malaria and the natives are comparatively affluent, the mortality during the first year of infant life was found[4] to be 158.3 per 1,000 births at the time of a recent visit of inspection. In malarious countries, such as the Mandated Territory of New Guinea, where certain areas are still unexplored and where there exist all intermediate stages, the infantile mortality recorded varies from 120 to 149 per 1,000, and is probably much higher.

The maternal mortality rate at lowest is 18 per 1,000, while in some districts it rises to the extremely high figure of 65 per 1,000, and there is a probability, owing to the difficulty of collection and correction of statistics, that the actual state of affairs is worse. Even where children are successfully born, however, they are subjected almost immediately to difficulties in the matter of feeding, and also to the menace of malaria in most parts of Melanesia. It is not an unusual thing to find a child of 2 or 3 weeks being fed on chewed taro, or, indeed, handed over to the clumsy attention of some half-grown girl in the village. Irregular breast-feeding and an entire lack of attention subsequent to the birth of another child, say in fifteen months, result in a very high death rate during the first three years. It is common to find a woman who has borne eight children, of whom only one or two survive, and these only because the interval between each and the next was more than two years, and consequently permitted the attainment of relative self-sufficiency before the attention of the mother was withdrawn to a younger infant.

INTRODUCED DISEASE

A matter of importance in connexion with the decline of native populations in Melanesia is the consequential Asiatic immigration, already obvious and increasing. In past decades it affected to a great extent the disease pictures in areas otherwise similar. The introduction of amoebic dysentery, for example, appears to coincide almost exactly with the introduction of Asiatic immigrants from India and China, and the same statement is approximately true with regard to the distribution of ankylostomiasis, ascaridiasis, and leprosy. (At present hundreds of Annamites and Tonkinese are being brought into the New Hebrides by the French yearly.)

INADEQUATE AND FAULTY DIET

In the less-developed localities, where European intrusion is of later date, it is still to be observed that planters and traders and their established plantations pin the native down to fixed localities, greatly restricting the areas available for his gardens. As a consequence of this fact, and the inelasticity that characterizes native habits, he becomes resigned to an inevitable decrease in the available food supplies. That it is this decrease in available subsistence that limits population is obvious on inquiry.

For example, an official examination[14] undertaken in the north-west Pacific islands some years ago demonstrated that where food was deficient there was a faulty nourishment of pregnant women, a diminished virility of the offspring, and increased actual failure of impregnation. In some localities there was added a deliberate policy of abortion and infanticide, the custom of the native from time immemorial when food stocks were low.

Again, in Polynesia the people were undoubtedly more numerous about a century before the arrival of Europeans, and this was despite frequent wars—wars that became more frequent and more intense as the competition for land and foodstuffs became keener. The comfort of the people in many localities demanded that there should be no increase in the population, and the priests and elders devised an extremely interesting and ingenious social law. People of the lower subject class in their dual organization were enabled to aspire to higher rank by the systematic sacrifice of their children as they were born. To such lengths had the practice gone that there had arisen, as Ellis points out in his *Polynesian Researches*, a powerful semi-secret society, all the members of which were pledged to the destruction of any children that might be born to them. By this means, and by perpetual wars, the populations of many groups were already declining from their overplus at the time of the European discoveries, and writers have sometimes been tempted to lay the flattering unction to their souls that depopulation may be called a "natural process."

In Queensland very similar factors are found to operate. The birth rate is as high as 40 per 1,000, but the aboriginals have succumbed very rapidly to diseases introduced by the white man, and in particular to tuberculosis and other respiratory infections. The outstanding defect observable among them is the lack of tone and of resistance set up by a faulty diet, that robs them of the stamina necessary to meet the conditions that invade and disrupt their specialized environment. An official examination of the populations of the mission stations in North Queensland recently demonstrated that whereas between 80 and 92 per cent. of the natives had excellent teeth immediately after the second dentition, yet by the age of 30 only 30 to 39 per cent. had teeth which could be regarded even as fair, and that with each decennial period there was a rapid decrease in excellence. At 40 the proportion of good teeth had fallen to 19 per cent. and by 50 to 9 per cent. After 50 years of age not one perfect set of teeth was apparent, many natives were edentulous, and many preserved only a few foul, loose, and filthy stumps.

This was my experience also in connexion with the rapidly declining population of the islands of Matti and Aua,[14] in the North-West Pacific. In Auna Village, Matti, 80 per cent. of the men and 76 per cent. of the women showed pronounced dental defects of this nature, while 6 per cent. were edentulous. In Aua the percentage was markedly less, and this was definitely in accord with the fact that in this island the available food supplies were richer in vitamin content and the diet altogether more varied and better balanced.

A lengthy experience among native populations once considered remarkable for the excellence of their teeth has seemed to me to confirm very definitely a statement of McCollum and Simmonds that:

> "The researches in the field of nutrition have a greater value in preventive medicine in relation to raising the vitality of mankind, with all that this implies, than they have in the prevention of the occurrence of the deficiency diseases. This fact has never been sufficiently appreciated. . . .
>
> "It is the gradual operation of more or less constant but unperceived causes rather than of great exposures of an accidental nature which in most cases is responsible for undermining the health of the individual. Of these causes it now seems certain that the consumption of an improperly constituted diet is one of the most important. It is one of the causes of inferiority in physical development, instability of the nervous system, lack of recuperative power and endurance, and a consequent cumulative fatigue and lack of resistance to infections such as tuberculosis and other types where specific immunity is not easily developed by the body. In addition to this, the rate of development of senile characteristics, and consequently the length of the span of life, are greatly influenced by the type of diet to which one adheres."[15]

It is this, and not Spengler's metaphysical hypothesis, that may explain the decay of primitive and sophisticated alike, for there is no less evidence that the same conditions occur in people resident in cities, where the difficulties in obtaining a properly balanced diet and live food are marked. The fact that a relationship exists between faulty feeding and nervous diseases has been more and more substantiated, whether it be in relation to canine hysteria or factors that affect the nervous stability and physical resistance. (One recalls with passing interest that marked caries was found in the teeth of the ancient Egyptians of the civilized period.)

Excess or deficiency of the gastric secretion is another matter to which city life seems to conduce—one may instance also the spectacular frequency of peptic ulcer during this depression—and I have for some time held the view empirically that a loss of fertility among city women, or a lessened fertility at increasingly early ages, is derived from an alteration in the *p*H of the vaginal secretion, dependent upon nutritional causes. The lack of skin tone as seen in breast and perineum among ill-fed or "citified" stocks is also a commonplace to those who have observed well-fed native stocks.

Conclusion

From the grand plane of Spengler's cosmic rhythms and rapidly flitting millennia, I have descended to the saturated population of Japan, the possible stalemate of our own "moonlight" civilization in Australia, the uncertain tilt towards decline of the primitive populations of Oceania, and a thinning series of isolated observations and speculations. One thread, however, connects the series—it is the interacting influence of population upon subsistence and subsistence upon population, and I will go so far as to add that this makes up history.

While it may be, and indeed seems, true, as Spengler says, that human decline follows inevitably upon that stage of megalopolitan existence he describes as "civilization," it is not specific to it, and there is no factor, whether it be failure of "soul substance" or of vitality and initiative, its disillusionment, or its mental, physical, and moral decline, that is not found among the primitive savages in their native jungles when they are brought into circumstances that curtail the qualtiy and quantity of their accessible subsistence.

Malthus has inferred that the great curves of the population graph are governed by food, both as to rise and fall. It may be that these again, in the final analysis, refer back to sun-spot cycles or other phenomena governing weather from stage to stage, and with weather plant growth—the final factor in geographical and perhaps economic determinism. Left to himself, and adapted to his environment, man makes no change while he meets no pressure from without, but let a cycle of plenty enhance his fertility, or a cycle of drought bring him hard up against the pressure of subsistence, and so face to face across his natural frontiers with similarly expanding tribes, and conflict becomes inevitable.

A people specialized to its environment needs peace and security for its continuance. The narrow margin between food and famine, or the mass subordination to a ruling group, makes a culture susceptible to any sudden reversal, and its people as defenceless and unresisting as a flock of sheep.

The overflow of the West submerged the Pacific in a wave of arrogant commercialism, seeking new markets, raw products, and new homes. In Australia it displaced the aboriginal; in Oceania it has balanced the population on a knife-edge of survival; the East Indies it laid under tribute for 300 years, India for two centuries, China for one; and in Japan produced repercussions of a kind familiar to high history.

As Japan was led from a balanced self-sufficiency into the race towards industrialization, her population increased enormously and her ability to export food and raw materials fell correspondingly. But importation of food can only be profitable if it is paid for in manufactures, and it reacts to the disadvantage of the Japanese agriculturist in any case. Already 43 per cent. of the population is in dire straits, and as the price of manufactured goods rises, the purchasing power of agricultural products must drop, to their further detriment. Moreover, as the technique of production improves, unemployment increases, and the unemployed moiety, not having sufficient individual and collective purchasing power, becomes an increasing impediment and burden to profitable production. In any country nominal increase of wages merely contracts the exporting power, and the attempt to support both local industry and local agriculture by protective tariffs tends dangerously to economic isolation.

In the East, the consequences of all these tendencies can be only three: a lowering of the standard of living, with untold misery; a tremendous deliberate contraction of population; or an outlet for the population in new territory that may serve to bridge the lag beween population and employability—that is, subsistence. Japan has chosen the only alternative consistent with her exalted nationalism—she has extended to the Equator in the South (her sampans are permanently established on our northern coasts); she extends to the Arctic north and is developing a new contest with the Soviet for Sakhalien and its fuel supplies; and in the west she has absorbed Manchuria and dominates Mongolia. But she began late; her people are reluctant to emigrate, and her available soil is utilized even beyond its maximum efficiency. The diet of her people is to an uncertain degree deficient; and the nationalistic doctrine has identified reduction of population with national debility.

In Australia population was attracted by gold and held by wool, wheat, and beef. True to the "moonlight" nature of our culture, we have waxed and waned as the circumstances of the homelands dictated. Our standard of living set an early limit to industry or agriculture, and our expansion is governed by geographic controls that are assisted by a striking mental conversatism that expresses itself in very real food deficiencies on the frontiers of our civilization. Trachoma, for example, in somewhat more than a century, has moved from the neighbourhood of Sydney to the arid lands of the interior, keeping always upon the advancing edge of colonization, with its deficiencies in milk and greens. Griffith Taylor, who was by no means an optimist, estimated our possible population to be 60,000,000—roughly that of Japan proper to-day; it appears that our stable population, as mentioned above, will not exceed a stalemate at 8,500,000, unless a radical change is effected by circumstances.

Prophets of evil are ever unwelcome, and I have suggested no outlet for optimism in this story. Australia depends to-day for her defence and her development upon peace and security, for which there is no guarantee. Italy, Russia, Germany, and Japan, discounting any reliance upon conciliation and concession, have encouraged a hypernationalism that might rapidly become imperialistic in practice. Germany, indeed, lamented by Fischer as a moribund community in 1931, has responded to the challenge of the policy of the Third Reich by a surprising increase in the birth rate, and an almost religious attachment to the policy of health. The whole nation is orientated to a nationalism based on ideal health, with health as a national duty. Meanwhile, the economic war continues and intensifies, and while the attempt at self-sufficiency restricts the subsistence level of the future in terms of population, the steady trend of thought towards idealistic socialism limits ambition, cools ardour, and lowers vitality in a national sense.

Health—that is, protection against external disease, and a vigorous vitality from right living that is internal excellence—and the dominant mentality that goes with abounding health, are both essential to ensure our survival in the period of increasing pressure in the Pacific that appears imminent and inevitable.

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AUSTRALIAN AERIAL MEDICAL SERVICES*

BY

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The Aerial Medical Service, commonly known as the "Flying Doctor" Service, is indelibly associated in the minds of the Australian people with the name of the Rev. John Flynn. No association of ideas was ever more just, for it is due almost entirely to his inspiration and tenacity of purpose that the Aerial Medical Service exists to-day. His work as superintendent of the Australian Inland Mission (the Bush Department of the Presbyterian Church) has, since 1912, taken him constantly into the huge sparsely settled areas of our back-country.

In Australia close settlement, even as we know it, is confined to the eastern and southern fringes of the continent. Over the remainder, in an area larger than western Europe, are scattered thousands of settlers, whose nearest neighbours are of the order of a 100 miles distant, and whose nearest hospital and doctor are often 200 miles away. Their means of communication, in most cases, is primitive, a ride on horseback of sixty or seventy miles to the nearest telegraph station being quite common. Their only means of transport is by roads, which are merely bush tracks, and even this is often denied them during the wet season, when heavy rains transform the tracks into quagmires and the water courses into torrents. Much of this huge tract is settled by men with their wives and families, but in the more remote areas there are very few white women. In normal circumstances their isolation causes them little concern, but in time of acute illness the delay in securing medical advice, and the slow, painful journey over rough roads to hospital, constitute a nightmare to the patient and his friends, and in many cases lead to a fatal issue, which in more favourable circumstances could certainly be obviated.

How the Problem was Attacked

Realizing these things Mr. Flynn attacked the problem of supplying improved medical facilities for these present-day pioneers. Acting under his inspiration, the Australian Inland Mission has established at some of the most isolated outposts small hospitals, which are staffed by two trained nurses. Many of these hospitals have now been in existence for twenty years, and have built up, both for the Australian Inland Mission and for the magnificent women who have successively staffed them, a peerless reputation for service to the people of the back-country, irrespective of class or creed. Depending on land transport, however, these hospitals can serve only a comparatively limited area. Mr. Flynn early realized the possibilities of the aeroplane, and conceived the idea of having a doctor established at a central base, and using an aeroplane, not only to reach the patient, but also to transport the patient to an adequately equipped hospital for treatment. But of what use to have such a service unless some means existed whereby the outback settler could summon the doctor to his aid! Mr. Flynn's solution was "give them wireless."

When these ideas first took shape in the years just before the war both aviation and wireless were much too primitive and unreliable to enable the vision to be translated into reality. Improvement in the aeroplane came quickly with the stimulus of war, and before many years had passed the scheme became practicable in so far as flying was concerned. Wireless was much more difficult. To design a complete wireless station, so cheap as to be economically possible for outback people, and so simple that they could maintain and operate it themselves, occupied several years of experiment and the expenditure of several thousand pounds by the Australian Inland Mission. Eventually, however, in 1926, success crowned their efforts. The result was a complete transmitting and receiving set, embodying several unique features, which stands as an enduring monument to the ingenuity of Mr. Alfred Traeger, our chief wireless engineer.

The two major technical difficulties were now overcome. It remained but to make the scheme financially possible. Several years previously a special fund to finance it had been begun by the Australian Inland Mission. To this fund had contributed numerous philanthropic individuals and organizations, chief of which was the H. V. McKay Charitable Trust. By 1927 this fund had grown to £7,000.

In May, 1928, the first aerial medical service base was established at Cloncurry. The first civil organization of its kind, it was regarded as purely experimental, the intention being to operate for one year to test its practicability. By the end of that first year all doubts as to its real usefulness had been dispelled, and it was decided to continue its operations as long as funds should permit. Seven members of the medical profession in Australia have, in succession, acted as medical officer in charge at Cloncurry for periods ranging from six months to three years. Flying and wireless equipment have been improved and extended as need and opportunity arose, and the scope and variety of the work done is constantly expanding, while to the people whom it serves the Aerial Medical Service is no longer a novel experiment, but a proven safeguard to be relied upon in their hour of need.

The Cloncurry Base

The central wireless station, specially designed and built by Mr. Traeger, employs a maximum power of 500 watts, and may be operated on either of several wave-lengths which we have found, by experiment, to be particularly suitable for conditions in our area. It is in charge of a very capable full-time operator with one assistant. Messages outwards to the small sets are sent in ordinary voice so that reception at the outposts is as easy as listening-in to a broadcast programme. The small sets, which are installed in isolated homes, embody several ingenious features, chiefly directed towards making possible their operation and maintenance by previously untrained people.

These outpost sets not only receive but also transmit messages to the Cloncurry base. The source of power for the transmitters is a small high-tension generator driven by bicycle pedals, thus avoiding the maintenance of a complicated engine and the necessity for an unfailing supply of fuel. All that is necessary is man-power. For distances up to 200 miles communication from an outpost set to Cloncurry (or between two outpost sets) may be carried on in ordinary voice. For greater distances it is preferable to use Morse code. To simplify the sending of Morse code for the bush people Mr. Traeger embodies in these sets an automatic transmitter. This instrument has a keyboard very much like that of a typewriter, each key being marked with a letter or numeral. All that is necessary is to depress the keys in the required sequence, according to the message it is desired to transmit, whereupon the automatic transmitter sends the corresponding Morse code signals, perfectly made and spaced.

Each year we are adding to the number of these outpost sets as circumstances and funds permit. There are now thirty-five, and they are situated in a great variety of places: pastoral station homesteads, Australian Inland Mission hospitals, lonely police stations, and mission

* Read in opening a discussion in the Section of Medical Sociology at the Annual Meeting of the British Medical Association, Melbourne, 1935.

stations of several creeds; in the vast plains of the interior, and on lonely islands off the coast; from the dry sandhills of central Australia to the tropical forests of the Cape Yorke Peninsula. These various situations have two things in common: isolation, and the lack of any other means of communication. The nearest outpost set is 120 miles, the most distant over 700 miles, from Cloncurry.

The outpost sets communicate daily with Cloncurry, at a prearranged schedule time, thus ensuring that, mechanically, everything is in order from day to day. Throughout the day, however, an operator is on watch so that an emergency call does not go unheard. Although installed primarily for medical purposes these small sets have proved of very great value in another direction. To oblige these isolated folk, we undertook to accept from them, by wireless, messages to be sent on as telegrams from Cloncurry Post Office. The replies, received by us in Cloncurry, are transmitted to them by wireless. From small beginnings this phase of the work has grown, until in 1934 we handled in this way a total of 185,000 words in telegrams. What this means to the outback people will be fully realized only by those who have lived under conditions of isolation. People who previously received a mail only at intervals of many weeks can now send a telegram to any part of Australia and have the reply on the same day.

The Ambulance Aeroplane

The ambulance aeroplane is a cabin type of machine adapted to carry a full-length stretcher, so that patients travel lying comfortably, and completely sheltered from the weather. There is room for the doctor to move about beside the patient, and a third person can be carried. A complete battery-operated transmitting and receiving wireless set is carried on this machine on all flights. It is operated by the doctor, who is thus enabled to keep in touch with his base. This provides an invaluable safeguard when flying over sparsely settled country, where a forced landing would be a very serious matter, more especially if a patient who was ill and helpless were being transported. When returning to hospital with a patient in need of urgent surgical attention several precious hours can often be saved by "wirelessing" ahead for the ambulance to be waiting at the aerodrome and the operating theatre to be prepared. In a small country hospital the preparation for an emergency major operation takes much longer than in a metropolitan operating theatre; the value of being able to save these two or three vital hours is too obvious to need any emphasis.

Naturally, much of our flying is done off the beaten track of the commercial route. We have to ensure, therefore, that adequate supplies of petrol and oil are available at outlying places. In one instance these supplies are carried 400 miles from the railhead by camel. At that "dump" our petrol costs us 4s. 6d. per gallon. We have stimulated many settlers and the residents of small towns to prepare landing grounds, where otherwise there would be none. Apart from its immediate value to the Aerial Medical Service, this ground organization, which is being gradually built up, is sure to stimulate the development of aerial transport for general purposes.

Medical Advice by Wireless

The activities of the Aerial Medical Service fall into several classes.

Since wireless messages from Cloncurry to the outpost "pedal" sets are transmitted in ordinary voice, the doctor can, on a case being reported, readily ask any questions necessary to make a provisional diagnosis and then give detailed instructions as to treatment. This would be quite a slow and cumbersome process if Morse code had to be used, especially with the untrained operators at the outpost sets, but with a powerful transmitter working radio-telephony it is very little more difficult than using a telephone. In many cases such advice is only given as a measure of first aid until the doctor can arrive by air to see the patient. In some cases, however, the doctor decides that the patient may be treated by his friends or relatives, who report progress and receive further instructions by wireless at appropriate intervals. Thus in suitable cases the expense of hundreds of miles of flying can be avoided.

At first sight it does not seem of much importance that we should be able thus to advise the outback people in regard to their less serious cases of illness. Let us consider, however, the minor illnesses of children. We all know how worried the city mother becomes when her children are suffering from, say, acute gastro-enteritis or the "convulsions" associated with teething. This city mother has doctor, ambulance, and hospital all within easy call. Imagine the plight of the outback mother who has not even another white woman to help her, and whose doctor and hospital are 200 miles away, over rough and, maybe, impassable roads. For her the wireless set in the house, bringing her into direct touch with the "flying doctor" hundreds of miles away, is a comfort of the highest order. In many cases a few simple instructions are all that is necessary to relieve the patient's distress and the mother's anxiety.

Emergencies

It is, however, in cases of grave emergency that the Aerial Medical Service is seen at its best and has its greatest sphere of usefulness. In a country devoted mainly to cattle-raising and mining there naturally occur a considerable number of violent accidents, with, all too commonly, severe cranial and abdominal injuries and broken limbs. There are also, of course, the common surgical emergencies: acute appendicitis, perforation of a peptic ulcer, rupture of an ectopic gestation, and so on. I have also seen, even in these remote districts, cases of diphtheria and one case of acute anterior poliomyelitis.

The value of the Aerial Medical Service in such cases will be apparent. It alone can provide the means whereby these patients may have the benefit of the prompt attention with resultant early diagnosis, and the speedy, comfortable transport to hospital, which are so vital if lives and limbs are to be saved. The combination of wireless and flying means a saving, in many cases not merely of hours, but of days. Even where the time factor is not vital, the comfortable transport by air is in itself of very great value. This is particularly so in cases of fracture of the long bones. The patient transported by air is remarkably free from surgical shock due to pain, which is practically a constant feature when these patients have to be brought even comparatively short distances over rough roads.

Here, then, are life-saving factors in the treatment of grave medical and surgical emergencies occurring in isolated places. In most cases we prefer to claim only that the result has been a saving to the patient of much mental stress and pain, a reduction in length of illness, and, perhaps, the prevention of permanent disability, but each year of our operation we are able to look back upon at least two or three life-saving flights—cases where death would certainly have been the outcome had there not been available to the patient prompt and adequate medical attention.

Secondary Cases

When the nature of the primary case is such that there is not any immediate hurry to return to hospital the doctor can often delay a few hours and thereby see a number of patients suffering from chronic complaints, who, in many instances, have had no opportunity of consulting a doctor for years. Timely attention to eyes and teeth, to mention only two possibilities, are invaluable to these isolated people.

Co-operation with Other Doctors

At each of six small towns within the area covered by the Cloncurry base there is a resident medical practitioner, who is guaranteed a modest income by the local hospital board. At each town there is also a small hospital, usually staffed by one trained nurse. These practitioners are separated from each other by hundreds of miles, and their only communication is by telegraph. At these small hospitals the equipment, as a rule, is meagre; lack of

refrigeration makes it impossible to keep sera and other perishable products, and an *x*-ray plant is out of the question. Naturally there are occasions when these isolated practitioners would very much like to see a colleague in consultation ; to have professional assistance at major operations ; or to be able to obtain certain sera, drugs, or equipment which they do not, or cannot, keep in stock. Before the advent of the Aerial Medical Service these wishes were impossible of realization, and these men had to fight their medical battles single-handed and handicapped by inadequate equipment. But times have changed. All that is now necessary is a message by telegraph or wireless to the "flying doctor," and within a few hours a second opinion and the necessary equipment are at the disposal of the isolated doctor and his patient.

The following story illustrates the possibilities.

We received in Cloncurry one morning a telegram from a doctor in practice in a small town 250 miles away. He had several patients in hospital, and his only nurse had been stricken with acute bronchopneumonia secondary to influenza, which she had had to neglect in an effort to care for her patients. He requested my assistance, more especially to provide, if possible, a cylinder of oxygen and a nurse. We had a cylinder of oxygen at Cloncurry—the only one within a radius of hundreds of miles—but we could not spare a nurse, as our staff had been sadly depleted by an epidemic of influenza. On inquiry, however, I found that a nurse living privately in a town 130 miles from Cloncurry and almost on our route was willing to come. Leaving Cloncurry with the oxygen on board we flew 130 miles, picked up the nurse, who had never flown before, and had both nurse and oxygen "on duty" at the patient's bedside, 250 miles distant, within six hours of the receipt of the call.

In other cases in which, after consultation, it is considered advisable, the patient is transferred by air to Cloncurry, where an *x*-ray plant and more complete surgical equipment are available. In still other cases we simply act as a transport unit to carry a patient from an outlying place to the nearest hospital at the request of the doctor in charge. This doctor has perhaps been called out forty or fifty miles over rough roads to see a man with a fracture of the skull. Transport by road is impossible and nursing on the spot equally so. The ambulance aeroplane is available on request, even though it may have to fly 400 miles, to transport the patient forty miles to his district hospital.

This spirit of friendly co-operation has done much to extend the work of the Aerial Medical Service, and more than one doctor in practice in these isolated places has expressed the opinion that the "flying doctor" scheme is as great a comfort to the doctor himself as it is to the patient under his care.

Supervision of Outlying Hospitals

In the Cloncurry area are two small hospitals, which, owing to financial stringency, have recently not been able to provide a salary to retain a resident medical officer. They have had to attempt to manage with just a trained nurse in charge. One of these hospitals is at Kynuna, 120 miles from Cloncurry, and the other at Burketown, 230 miles distant. It was certainly not fair either to the nurse or to the patients that they should thus be virtually beyond human possibility of skilled assistance or attention. We endeavoured, as a temporary measure, to supervise these hospitals by air from Cloncurry. So well did the scheme work that the "flying doctor" was officially recognized by the Queensland Government as the medical officer in charge of both hospitals. To the residents of closely settled districts it must seem rather unusual that a doctor, in addition to being on the staff of the hospital in his own town, should also be the medical officer in charge of two other hospitals which are 450 miles apart. We have always regarded this arrangement as temporary only. We have constantly encouraged both towns to appoint a resident practitioner, and this has recently been done at Burketown.

"The Mantle of Safety"

It remains to mention but one more aspect of Aerial Medical Service activities, and it is by no means the least valuable, even though it entails no active work whatever. I refer to the greatly increased feeling of security imparted to residents of the outback by the very existence of the Aerial Medical Service, which has spread over them what has been most aptly called "a mantle of safety."

We feel, most emphatically, that Australia cannot claim to have begun adequate settlement of her vast back-country until life there has been made reasonably safe, not only for men, but also for their families. The presence of white women and children is a vital factor in maintaining the cultural and moral standards which make for satisfactory permanent settlement. There are still plenty of women of the poineering type who are willing to accompany their men to these isolated places, but many men hesitate to take a white woman out there, principally for the reason that they realize their utter helplessness in the event of illness or accident befalling her. With the advent of children this haunting fear is ever-present in the minds of both husband and wife.

In the area served by the present Aerial Medical Service base a very different feeling has been engendered. These settlers now know that, providing they have an adequate means of communication with the "flying doctor," and have prepared a suitable landing ground near their home, there exists an organization which is able and willing to help them in time of need. The value of this feeling of security in promoting peace of mind will only be fully realized by those who have lived in isolated places. We claim, in all sincerity, that it is a definite stimulus to satisfactory permanent settlement, and that, as such, it has a very real national importance from the economic as well as from the humanitarian viewpoint.

Range and Variety of Service

The area which it has been found possible to cover by air from Cloncurry is one of approximately 400 miles radius—that is, an area possibly a little larger than the British Isles. Occasional flights have been made far beyond these boundaries, the longest yet made being 2,500 miles, in the course of which the patient was transported 1,250 miles. This unusually long flight was undertaken to secure in Brisbane the services of an ophthalmic surgeon for a young man who had sustained severe injuries to both eyes as the result of the explosion of a chemical refrigerator. But the wings of death flew with us. On the second day of the flight the patient developed an intensely toxic bronchopneumonia, presumably the result of inhaling the fumes of a secret compound which was used in the refrigerator, and we suffered the disappointment of seeing him die when we were almost in sight of our goal.

This flight, apparently in vain, was to lead directly to the much more happy outcome of another one only a few weeks later. At the time of our arrival in Brisbane there was a widespread epidemic of acute poliomyelitis. Through the courtesy of Dr. S. F. McDonald I saw a series of these cases, and as I intended to fly back to Cloncurry in one day I was able to take back, packed in ice, a supply of poliomyelitis serum. Less than a month later a call was received to a station homestead 120 miles from Cloncurry, where a boy of 7 years was found to be suffering from acute poliomyelitis in the pre-paralytic stage. Within two hours the patient was transferred by air to Cloncurry Hospital and had received the appropriate serum treatment, with the result that he made a complete recovery. One other case of poliomyelitis occurred in our area, at the neighbouring town of Mount Isa, 130 miles away, and we were able to supply to our colleague there enough serum for successful treatment of the case.

In these various ways the Aerial Medical Service is striving to improve the standard of medical service in the sparsely settled areas. We have been able to make available to these isolated people—patients and doctors alike—the services of city specialists and special hospitals, *x*-ray and laboratory diagnostic methods, and sera and surgical equipment, which have hitherto been beyond their reach. During a typical year (June 30th, 1932, to July 1st, 1933) it was necessary to undertake forty-five separate flights, aggregating 16,000 miles, the nearest place visited being seventy miles, the most distant 430 miles, from Cloncurry. In the course of these flights 200 patients were attended,

of whom at least thirty represented really serious cases of illness or accident, the remainder being less severe or "secondary" cases of a minor or chronic nature. Twenty patients were transported by air to hospital, and six were seen in consultation with professional colleagues. In addition, advice was given by wireless and telephone to seventy-three patients, whom it was not necessary to visit.

Recent Developments and the Future

We feel that the experimental Aerial Medical Service base has proved its worth. It has been said by a Minister of the Queensland State Government that the "flying doctor" scheme has been worth to Queensland ten times the money which has been spent on it. The technical difficulties of wireless communication have been overcome; a successful scheme of co-operation with pre-existing medical services functioning in the area has been evolved; and it has been shown that a "mantle of safety" can be spread over an area as large as the British Isles.

Such, however, is the vastness of inland Australia that there remain many isolated homes and many lonely settlers far beyond the reach of the present base. We have for years visualized a scheme providing for six such bases, which would cover the whole of the sparsely settled country. Such a scheme is much too ambitious for any one organization to undertake, even for the willing hearts of the Australian Inland Mission, who have sponsored the experimental service. Moreover, it is felt that this work is truly national in character, and therefore should attract the interest and support of the whole Australian people. At the same time it is hoped to retain to the utmost the attitude of disinterested public service which has been characteristic of the supporters of the Cloncurry experiment. Therefore, while a certain measure of Government support is desired and expected, it is hoped to keep the development and control of the scheme largely in the hands of public-spirited individuals and organizations. With this end in view, there has been formed an association known as "Australian Aerial Medical Services," of which all such organizations have been invited to become members. A section of this association is to be established in each State, with headquarters in its capital city. The Victorian section was formed in 1934, under the presidency of Dr. J. Newman Morris. The West Australian section is in process of formation, and sections will be established in other States as the opportunity arises. Many influential organizations have already joined the Victorian section.

On the council of the Victorian section are several members of the Victorian Branch of the British Medical Association. I may say in passing that throughout the whole period of its existence the Aerial Medical Service has acted in close collaboration with the British Medical Association, so as to ensure that its development should be in accord with the highest code of medical ethics. The Federal Council of the British Medical Association in March of this year resolved that general approval be given the Australian Aerial Medical Services scheme subject to the provision that the service in any State be kept in association with the council of the Branch of the British Medical Association in that State.

At the Premiers Conference of 1934 the service was discussed at length, and was commented upon sympathetically and favourably by the representatives of practically every State. Finally it was resolved:

> "That this Conference approves of a general co-operation of the Governments of the Commonwealth and the States with a view to furthering the Australian Aerial Medical Services Scheme."

Public subscription funds were opened by the leading newspapers in Melbourne and Perth, and have realized approximately £2,200 and £3,000 respectively. These various activities are already beginning to bear fruit. At the time of writing (March, 1935) it is anticipated that in the near future we shall be able to establish bases at Port Hedland and Wyndham, thereby bringing the second and third links in our proposed chain of six into being.

A Contributory Scheme of Support

With the establishment of these new bases it is hoped to organize a more systematic scheme of financial support from the residents of the areas served. In the past, in the Cloncurry area, we have been concerned mostly with proving the "flying doctor" scheme to be sound from the technical aspect. During this experimental era it has been necessary to operate practically as a free service. Patients have been expected to contribute whatever they could afford towards the cost of the flight made to reach them. This they have done willingly, but in only a few instances have they been able to pay the full cost. We do not consider that the individual patient should have to do so, as the payment of a comparatively large lump sum imposes considerable hardship. On the other hand, we do not believe in free service as a permanent institution, and the settlers themselves, who are generally of an intelligent and independent type, would like to make the service, as far as possible, self-supporting. The solution appears to be some form of contributory scheme, the details of which we hope to work out and apply within the next few years. Such a contributory scheme need not necessarily provide the full cost of operation. We hope to have the continued support of the Government, which realizes the nation-building value of the service, and there will still be, we trust, public-spirited people, who, living in closely settled areas and enjoying all the amenities of civilization, will regard it as a duty and a privilege to assist those who are not so favourably situated.

How many of our dreams will materialize only time will show. The Aerial Medical Service cannot fail to expand if it continues to attract the support which has been given in the past. Many individuals have contributed, but outstanding above all others have been four men: the Rev. John Flynn, who has dreamed of, and worked for, the service for more than twenty years; the late H. V. McKay, whose generous financial support has been a factor of the most vital importance; the late Dr. J. W. Dunbar Hooper, through whose wise counsel the experimental service was founded on principles in conformity with the highest ideals and ethics of the profession; and Dr. George Simpson, whose intimate knowledge of the back-country combined with his professional outlook has enabled him to play a vital part in the solution of aerial medical service problems.

Future Developments

We have still so much to do in Australia to develop our service from its present state, which we regard as the merest beginning, to the nation-wide organization to which we aspire, that only rarely can we permit our minds to wander beyond the confines of our continent. Nevertheless, we have been more than interested to receive occasional inquiries in regard to our activities from other countries, and especially from other Dominions of the British Empire. On such occasions we visualize the time when similar services will be in operation in other sparsely settled areas of the Empire; when Australian flying doctors, journeying to Great Britain on a scholarship after two or three years' service in our back-country, will meet there members of the Canadian and South African aerial medical services; when even these various Dominion services, though independently controlled, may be co-ordinated as "The British Empire Aerial Medical Services," with all the prestige which that great name would confer.

Whatever the future may hold, we believe that the Aerial Medical Service has proved that it merits a place in the scheme of things medical in Australia; that it has passed beyond the realm of the experimental and novel into that of the practical; that it presents a means whereby the profession of medicine may carry its healing art to a great number of people who cannot efficiently be reached in any other way, whose need in time of illness or accident is great, and who, as the present-day Empire-builders, not a whit less sturdy than those of the past, deserve well indeed of the country which they serve.

WEIL'S DISEASE IN NORTH QUEENSLAND*

BY

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In October, 1933, there appeared at Ingham, North Queensland, the first of a series of outbreaks of a disease which was regarded by Dr. G. C. Morrissey and Dr. T. Leckie as being entirely new to that district, and which was diagnosed clinically by them as Weil's disease. This is the first known occurrence of Weil's disease in Australia.

Ingham is a township of 2,000 inhabitants in the rich sugar-growing districts of North Queensland, approximately 18.5 degrees south latitude, lying about twelve miles inland in the richly watered flat country of the Herbert River district between the ranges and the sea sixty-seven miles north of Townsville. It is the main town of the Hinchinbrook Shire, which has a population of roughly 10,000. In the cane-cutting season, which commences about June and ends about January, there are some 900 cane-cutters with 100 gang cooks in the district. The area is in the wet belt, with an annual rainfall around 80 inches.

From October, 1933, over a period of a little more than four months, forty cases occurred, the appearance of the disease being sporadic in nature. In June, 1934, there was a recurrence, when thirty-two cases were seen over a period of three weeks. There was a short period of quiescence until August, when eighty cases were seen inside ten days. In September, 1934, six cases were seen within one week.

Symptoms and Course of the Disease

The mode of onset was almost invariably sudden, the patient usually giving up work and taking to bed within a few hours. Some patients complained of slight headache for several days previously. The initial symptoms were a feeling of coldness with shivering followed by fever. No definite rigor occurred.

The temperature was raised, usually reaching its maximum on the first day of the illness, but was never very high, generally ranging from 39° C. (102° F.) to 39.4° C. (103° F.). In most cases the pulse was comparatively slow in relation to the temperature. In every case there was pronounced conjunctival injection. There was great thirst and loss of appetite. Extreme mental depression was the rule. Marked lassitude and prostration were present. No definite rash appeared, although herpes labialis, haemorrhagic in character, was not uncommon.

Headache, which varied in severity but which was usually intense, was the most troublesome symptom. As a rule its situation was frontal and behind the eyes. Occasionally patients complained of temporal headache. Generalized bone, muscle, and joint pains occurred practically from the onset. Movements of the limbs were frequently painful. The outstanding symptoms at the onset were the headache and bone and muscle pains. The headache as a rule gradually increased in intensity, and was difficult to relieve. Sometimes patients complained of slight headache only. Prostration and mental depression increased. Profuse perspiration was noticed in some cases.

In addition to great thirst, anorexia was marked and vomiting common. In some cases vomiting occurred only after taking food and drinks, while in others it was frequent and unrelated to food. Constipation was usual, but sometimes diarrhoea occurred during the first few days of illness. Upper abdominal pain, which varied in severity, was complained of in about 50 per cent. A slight cough with scanty expectoration, pains in the chest, and a sensation of constriction were occasionally noted. Epistaxis was common, often occurring at the onset of the illness, and at times it was repeated and considerable in amount.

The skin frequently had an icteric tint, but as most of the patients were Italians with sallow complexions, this appearance was apt to be deceptive. In the very severe cases icterus was marked, and was often associated with petechial skin haemorrhages. The great majority of the patients recovered without being jaundiced.

The tongue was covered with white fur early in the disease, while later it became brown and dry. In many instances there was definite tenderness over the liver. Enlargement of the liver was absent or slight. In a few severe cases the spleen was enlarged. Enlargement of the axillary glands was always present. This glandular enlargement varied. As a rule the glands were not tender, but in one case a gland in the right axilla was enlarged to the size of a walnut and was very tender. The inguinal glands were palpable, but in none were they observed to be as enlarged as the axillary glands. In the mild cases nothing abnormal was found in the urine. Blood examination showed a polymorphonuclear leucocytosis. The van den Bergh reaction of the serum was negative in over 75 per cent. of a series tested between the sixth and tenth days of the illness.

Termination of Attacks

In the mild forms an improvement occurred on about the fifth day. The temperature fell and the symptoms abated, and in the majority of these cases convalescence was not prolonged beyond a few weeks.

In severe forms jaundice appeared about the fifth day and became very intense. The temperature usually fell to normal or subnormal about this time. Petechial haemorrhages and bleeding from the gums occurred in a number of these jaundiced cases. Vomiting was common and the vomitus was frequently brownish black, and tarry black stools (melaena) were passed. In some hiccup became troublesome, and was of bad prognostic significance. Mental symptoms, varying from a low muttering delirium resembling a typhoid state to acute mania, the patient frequently getting out of bed, occurred in several cases. Blood, albumin, and bile appeared in the urine, which became scantier as time went on, in some cases leading to complete anuria. In the first group of forty patients sixteen became jaundiced and four died. In the second group of thirty-two, four were jaundiced and two died. In the third group of eighty there was no jaundice and no patient died. In the fourth group of six patients one became jaundiced and died on the eighth day. In fatal cases death occurred between the eighth and fifteenth days. All patients who did not develop jaundice recovered, and of the 13.5 per cent. who developed jaundice one-third died, making the total case mortality approximately 4.5 per cent. The jaundiced cases which recovered became clear of jaundice about the end of the third and during the fourth week, and were usually fit for discharge from hospital in six to eight weeks from the onset of the illness.

Several very mild forms of the disease were recorded where the patients did not seek medical treatment, and one ambulatory case from Ingham showing typical symptoms (headache, upper abdominal pain, and generalized muscle and bone pains) and signs (enlarged axillary glands and tenderness over the liver) was seen at Townsville. This patient had been ill eight days, and had not been confined to bed.

* Read in opening a discussion in the Section of Public Medicine at the Annual Meeting of the British Medical Association, Melbourne, 1935.

As previously mentioned, convalescence in the mild cases was limited to two or three weeks, but a few were markedly debilitated and unable to work for many weeks. Convalescence was very prolonged in the severe ones, and was characterized by marked asthenia, anaemia, loss of weight, nervousness, palpitation, and shortness of breath on exertion. Pain in the back over the renal regions, and upper abdominal pain associated with nausea following meals, also occurred in some cases during early convalescence. In one instance a very marked general thinning of the hair with, in addition, areas of complete baldness was noticed.

Compensation for Weil's Disease

Under the Workers' Compensation Act, Weil's disease has been made a compensatable disease, and through the courtesy of the Commissioner, State Government Insurance, the following details regarding fifty-seven patients who received compensation through the Townsville office were made available:

Number of Cases	Periods of Incapacity	Number of Cases	Periods of Incapacity
7	1 to 2 weeks	4	7 to 8 weeks
15	2 to 3 ,,	1	10 weeks
15	3 to 4 ,,	1	12 ,,
9	4 to 5 ,,	1	24 ,,
2	5 to 7 ,,		

Two patients were still receiving compensation on April 13th, 1935, one for a period of thirty-six weeks, the other for over twenty-six weeks.

Post-mortem Findings

Two necropsies were performed by Dr. Morrissey and one by myself. In all cases the skin was deeply jaundiced, and generalized scattered petechial haemorrhages were present. The subcutaneous tissues were also bile-stained. In one the liver was moderately enlarged, the mucous membrane of the cystic duct was swollen, and the gall-bladder contained very thick bile. In another the spleen was markedly enlarged, being about two and a half times the normal size and deep red in colour. It was very friable, falling to pieces on removal, and appeared to consist of a mass of blood clot.

The kidneys were bile-stained, enlarged, and swollen, with small subcapsular haemorrhages. The capsules were not adherent. Small cortical and medullary haemorrhages were present. The pelves and calices showed submucous haemorrhages. Submucous haemorrhages were present in the alimentary tract. The lungs were congested, and in two cases showed scattered haemorrhagic areas.

Microscopical Pathology

Sections of organs of fatal cases were examined at the School of Public Health and Tropical Medicine, Sydney, and the findings were reported to be consistent with the changes found in Weil's disease. The liver showed cloudy swelling with occasional small haemorrhages. Cellular infiltration around the portal canals also occurred. Cloudy swelling and occasional areas of necrosis and degeneration of the tubular epithelium were observed in the kidney. Red blood cells and bile-stained granular debris were present in some of the straight tubules. The spleen invariably showed haemorrhagic areas. Small capillary haemorrhages occurred in the heart muscle.

Epidemiology

Clinical data and an epidemiological survey revealed that the patients were healthy adult males, all workers in the cane fields, being either cane-cutters or cane-growers with the exception of a cook, who carried meals to a gang through the swampy fields. Italians predominate among the farmers and cane-cutters, and constituted the greater number of those attacked, but men of all nationalities working in the cane fields have been affected. No women or children were attacked, and there was no record of case-to-case infection. At first the cases were widely scattered, but later as many as four in one gang were affected within a few days. An unusual number of wet days, with very high rainfall, occurred in the Ingham district in the year 1933, and as a result cane paddocks were waterlogged and swampy, and much surface water was present.

Heavy rat infestation is present in the cane fields, and a great increase of rat damage to cane during recent years indicates that this rat infestation is increasing. Prolific growth of harbourage in the shape of grass and undergrowth generally has been greatly favoured by the unusually heavy rainfall.

Location of the farms on which patients were working indicated a tendency for cases to occur on low-lying areas along streams subject to flooding, though these areas are those where most cane is grown, and are most heavily populated. Drainage of these areas generally is poor and rat infestation particularly heavy.

The outbreaks commenced shortly after the opening of the cane-cutting season, and ceased a few days after its close. The hands, wrists, and forearms of the cane-cutters are being continually scratched and cut by the lower leaves and ends of the cane, and contamination by the soil is unavoidable.

Laboratory and Field Investigations

At the beginning of the outbreak several specimens of blood and urine forwarded to the Commonwealth Health Laboratory, Townsville, gave negative results on dark-ground examination, and the results of guinea-pig inoculation were negative. No cultures of leptospirae were available for agglutination tests.

In July, 1934, at Ingham, guinea-pigs were inoculated intraperitoneally with blood from five human cases, and with urine from one case which proved fatal. All these patients had been ill for six or more days. From the fatal case a suspension of liver, spleen, and kidney was also inoculated into a guinea-pig. The guinea-pigs died at varying intervals from nineteen to thirty days after inoculation; post-mortem appearances were not characteristic, and no leptospirae were found.

On August 6th, 1934, further cases were reported by Dr. Morrissey, and seven guinea-pigs were inoculated with blood from cases in the second to the fifth day of the disease.

About this time Dr. J. H. L. Cumpston, Director-General of Health, authorized a field investigation, and on August 15th a temporary laboratory, in charge of Dr. W. C. Sawers of the School of Public Health and Tropical Medicine, Sydney University, was established at Ingham. On this and the following days four of the guinea-pigs inoculated on August 7th, 1934, died of typical leptospirosis. At necropsy they were deeply jaundiced with petechial haemorrhages into the skin, and haemorrhages into the subcutaneous tissues, particularly of the inguinal and axillary regions. The inguinal lymph glands were enlarged and haemorrhagic. The abdominal muscles were also haemorrhagic. Mucous and peritoneal haemorrhages were present in the stomach. Haemorrhages were present in the mesenteries and intestine, particularly the upper portion of the small intestine and the large bowel. The spleen was enlarged, and the kidneys and suprarenal glands were enlarged and haemorrhagic. There were haemorrhages into the retroperitoneal tissues and genital organs. The most striking feature was the occurrence of discrete scattered haemorrhages in the lungs.

Leptospirae of typical morphology were detected microscopically in saline suspensions of the liver, spleen, and kidney, and in the blood under dark-ground illumination. Catheter specimens of urine from a number of patients and convalescents, examined at Ingham, showed leptospirae which, however, were not quite as typical as those found in the infected guinea-pig. One animal inoculated with urine died about eight days later, but post-mortem findings were not characteristic, and no leptospirae were found in suspensions of the viscera. Re-inoculation of the suspension of the liver of this animal into another, however, caused death, with typical post-mortem macroscopic findings of leptospirosis, and leptospirae were demonstrated in preparations of the liver.

Leptospirae were found in urine in one case as early as the eighth day from the onset of his illness, and in another as late as the fifty-ninth day.

Examinations of Rodents for Leptospirae

At Ingham approximately sixty rodents from the cane fields and township were examined. Portions of the kidneys were ground up with sterile normal saline solution and the resulting suspension examined by dark-ground illumination. The rodents included the imported varieties *Rattus norvegicus, Rattus rattus, and Rattus rattus alexandrinus.* As Mr. E. Troughton, mammologist, Australian Museum, points out that *Rattus rattus alexandrinus* is merely the light phase of *Rattus rattus,* and that the whole range of colour variation of *Rattus rattus* may occur within one field or city locality or isolated place, such as Lord Howe Island, rodents exhibiting this light phase have been grouped under the *Rattus rattus* variety. Approximately 30 per cent. of rodents examined showed typical leptospirae in the kidney emulsions, and the pathogenicity of these organisms was established by guinea-pig inoculation.

Later, further examination of rodents at the Commonwealth Health Laboratory, Townsville, revealed some type variations, and the assistance of the Sydney School of Public Health and Tropical Medicine and of the Australian Museum was sought in identification. Rodents forwarded for identification included two indigenous species: the coarse-haired, short-tailed rat *Rattus culmorum* (easily confused with young *Rattus norvegicus*) and the scale-tailed rat *Melomys littoralis* (easily mistaken for young *Rattus rattus alexandrinus*). Six out of fifty-nine of the *Rattus culmorum* variety forwarded from Ingham were positive, and in three cases these findings were confirmed by inoculation. One *Rattus rattus* out of forty-five from the same locality was found to be positive. Fifty rats from Innisfail were examined with one positive finding, which was confirmed by the inoculation of guinea-pigs. At Cairns twenty rodents were examined, and one was found to be a carrier of leptospirae. Forty-nine rodents of the *Melomys littoralis* and *Rattus rattus* varieties from Tully and Ayr, both sugar-cane districts, were examined with negative results. Forty *Rattus norvegicus* and thirty-four *Rattus rattus,* from Townsville and Charters Towers, were also negative.

While the number of rodents examined is comparatively small, it would appear that the incidence of leptospirae in rodents in North Queensland, apart from the Ingham district, is very much lower than that recorded by workers in other countries. The most interesting and important fact that a native rat, *Rattus culmorum,* is the chief carrier of virulent leptospirae at Ingham has been established. The bandicoot, an indigenous marsupial, is common in the cane-field districts of North Queensland. Examination of kidney preparations of thirty of these animals revealed the presence of typical leptospirae in two from the Ingham district. Inoculation of kidney emulsion into guinea-pigs was carried out in one case, but proved unsuccessful, so as yet the pathogenicity of leptospirae found in the bandicoot has not been established.

Mode of Infection

The fact that the cases were confined to males, all workers in the cane fields, obviously suggests a field infection. Further, in favour of this was that practically all the cases occurred during the cane-cutting season. The association of rodents, many of them carriers of virulent leptospirae, and water, there having been an abnormal amount of rain during the year 1933 and first six months of 1934, strikingly illustrates what is generally found in other countries where Weil's disease is prevalent. The occurrence of most cases about ten days after rain and their cessation after a period of fine weather also points to the same conclusion. Regarding the site of entry of the organisms, it has already been stated that workers in the cane fields sustain numerous cuts and abrasions of the hands, wrists, and forearms, from the cane leaves and cut ends of the cane, and that soiling of these parts is unavoidable. Rats urinate on the cane when feeding and also on the soil in the vicinity, and the most probable portal of entry of the organisms is through these skin abrasions. Cane-cutters frequently use poor footwear, and some go bare-footed, and abrasions of the feet and of the regions around the ankles may also permit entry of the leptospirae.

Against the possibility of the infection being conveyed by ingestion of food or drinking-water is that families of cane farmers have not been attacked, although in many cases both food in the houses and the wells from which drinking-water is obtained are open to contamination by rats.

Preventive Measures

In August, 1934, an industrial crisis occurred. On account of the dread of the disease a strike was declared by the cane-cutters. On the recommendation of Dr. John Coffey, State Commissioner of Public Health, an order was issued by the Arbitration Court making the burning of the cane before cutting compulsory. Cane sufficient for one day only was to be burnt each day. Acting on the assumption that the disease was contracted through the broken skin, and that when the cutters were working in the fields the leaves and lower ends of the cane were continually scratching their hands and forearms, which were also coming into contact with the infected soil at the base of the cane, the burning of the cane was recommended to destroy the lower leaves, which would to a great extent prevent injuries to the hands. At the same time the heat would sterilize the cane and the ground underneath, so that there would be less danger of infection. In addition, the rats would be temporarily driven out of the burnt area. The burning of cane, however, presents practical and economic difficulties.

Complete extermination of rodents is impracticable, but a vigorous campaign of rat destruction has been embarked upon by the State authorities. It is estimated that cane farmers in the Ingham district alone lose about £60,000 annually through rat destruction of cane. Rat Prevention Regulations have been enacted declaring rats, mice, and bandicoots noxious, and detailing measures to be taken by owners and occupiers for the prevention and control of breeding and harbouring of these animals. These measures include the control of waste food, the cleaning up of litter, rubbish, and vegetation liable to act as harbourage, and the rat-proofing of places where food is produced. Similar measures are to be taken by the local authority, which is required to investigate reports of rat infestation upon premises and take effecfive measures for their destruction. The local authority is required to take measures prescribed for owners and occupiers in respect of roads, sewers, lands, and premises under its control. These regulations are as yet only applied to that portion of the Hinchinbrook Shire in which cases of Weil's disease have occurred.

The presence of innumerable burrows amongst the cane shows that the cane fields themselves, in addition to uncultivated land and the numerous water-courses, act as harbourages for rats. Undergrowth is being repeatedly cleared and burnt. The burning of the cane and the undergrowth deprives the rats of their cover and exposes them to their natural enemies. At regular intervals after destruction of harbourage, poison baits are distributed over the whole area. The high rainfall, the humid climate, and the rich soil of the cane fields extending north of Townsville up to Cairns favour the rapid and abundant growth of vegetation, and consequently the effective clearing up of rat harbourage would appear to present a constant and difficult problem, more particularly from the economic aspect.

Drainage of the cane farms would be helpful, but here again the economic aspect renders satisfactory drainage schemes impracticable. The use, in the cane fields, of antiseptic fertilizers has been suggested. Calcium cyanamide, which is prepared on a large scale by heating calcium carbide with nitrogen under pressure, and which undergoes decomposition in the soil with the production of calcium carbonate and urea, the urea being hydrolysed to ammonium carbonate by certain organisms in the soil,

has been used with satisfactory results in certain heavily infected rice fields in Japan, the incidence of Weil's disease amongst the workers in the fields being markedly lessened. The rice crops in these fields were also very much higher, thus illustrating the great fertilizing properties of this substance. Its use in such large areas as are infected at Ingham may not be practicable.

Cane-cutters have been advised to wear adequate footwear, to wash the hands before eating food in the fields, and to avoid using water lying in the fields unless it has previously been boiled. Antiseptics are to be applied immediately to all cuts and abrasions, which should then be protected by adhesive plaster.

The question of human carriers has to be considered. Leptospirae have been known to persist in the urine up to one hundred days. It is generally agreed that there is little or no danger of transmission of the disease to another human being. Schuffner,[1] however, reports a possible case of conjugal infection, where the disease was apparently acquired by a woman as a result of sexual intercourse with her husband. There has been no record of case-to-case infection in the Ingham outbreaks.

Prophylactic vaccination has been tried in Japan with encouraging results, and appears to be worthy of a trial. Experiments dealing with serological properties confirmed by vaccination will be discussed later in this paper.

Cultivation of Leptospirae in Artificial Media

Infected guinea-pigs were forwarded to the School of Public Health and Tropical Medicine, Sydney, and also to the Commonwealth Serum Laboratories, Melbourne, and cultures in various media were obtained from the blood and organs of these animals. Inoculation of the heart blood of the infected animals was found to be the most satisfactory procedure. Leptospirae have also been cultivated directly from the kidneys of an infected rodent. The medium we have found most satisfactory is the sloppy agar medium recommended by Fletcher,[2] and the cultures are incubated at room temperature. Four human and three rodent strains are now in culture, and show rapid and abundant growth with band formation in Fletcher's medium.

Using Hindle's method of faecal culture, leptospirae have been cultivated from Townsville tap water, drain slime, brackish water, and sea water. Pure cultures of leptospirae from Townsville tap water have been obtained by filtration of a faecal culture through an L3 Pasteur-Chamberland filter and inoculation of the filtrate into Fletcher's medium. These leptospirae show rapid abundant growth, band formation in many cases being marked within seven days or less after inoculation, and morphologically they appear to be longer and possess more open coils than the human and rodent strains, while their extremities are usually less incurved or hooked. Intraperitoneal injection of cultures of these water leptospirae into guinea-pigs has failed to cause Weil's disease, and agglutination and Pfeiffer's tests against sera of convalescents from Weil's disease were negative.

It would appear that leptospirae cultivated by this method are purely saprophytic, and that saprophytic water leptospirae can be found in practically any water.

Leptospirosis in Guinea-pigs

Virulence of pathogenic strains has been preserved by passage through guinea-pigs.

Suspensions in saline of infected liver were injected intraperitoneally into guinea-pigs, and, after a series of passages, the animals generally died of leptospirosis between the fourth and the seventh day, the macroscopic findings being usually characteristic. Occasionally variations have been noticed with regard to necropsy findings. The intensity of the jaundice has been found to vary markedly. The haemorrhages into the subcutaneous tissues, muscles, alimentary tract, mesenteries, inguinal glands, suprarenal glands, and kidneys were also found to vary markedly as to frequency and degree. In a few instances jaundice and haemorrhages into the above organs were entirely absent, but the characteristic areas of haemorrhages in the lungs were constantly present. Leptospirae were found to be scanty in saline suspensions of liver and other organs from some of these animals dying with atypical findings, and they could not be detected in several cases. Reinoculation of these apparently negative suspensions, however, produced the typical disease with positive macroscopic and microscopical findings. Occasionally the injected animals died within a few days from peritonitis or from intercurrent infections such as pneumonia.

Serological Reactions

During the Ingham outbreaks no cultures of leptospirae were available for the purpose of carrying out agglutination reactions, but more recently the sera of a number of convalescents have been found to give positive agglutinuation reactions in a dilution of 1 in 300 or over with cultures of leptospirae originally isolated from their own blood or urine, other human strains, and rodent strains. Convalescent sera were also found to give positive Pfeiffer reactions.

In a number of instances the same serum was tested against all our local strains of leptospirae, and the reactions were invariably positive. Suggested by the work of Buchanan,[3] protective experiments were made in which fixed quantities of suspensions of infected guinea-pig's liver in 0.85 per cent. saline were mixed with varying quantities of convalescent sera, and the mixtures injected intraperitoneally into guinea-pigs. Mixtures containing normal human serum in place of convalescent sera were injected into other animals as controls. These controls died of leptospirosis within the usual time, while it was found that the convalescent sera were highly protective against all strains of leptospirae. Provided an adequate amount of immune serum had been used the animals survived, and thereafter were immune to not only the strain injected but also to other strains.

Later, convalescent serum in quantities varying from 0.5 to 1 c.cm. was added to about 7 c.cm. of Fletcher's medium before inoculation, and, as described by Fletcher,[4] the leptospirae were found to grow diffusely throughout the medium, granular formation being marked. Dark-ground examination showed many leptospirae growing in agglutinated masses, an appearance not observed in control cultures, which also showed the usual band formation limited to the upper portion of the medium. This phenomenon was manifested by several human and rodent strains when inoculated into media containing the same convalescent serum.

Although absorption tests have not been carried out, the findings in the above experiments would seem to suggest that the local pathogenic strains of leptospirae are at least closely related, if not identical, serologically.

Serological Reactions of Vaccinated Human Subject

Prophylactic vaccination of field workers has been suggested, but as yet no trial of this procedure has been made. Very little laboratory work has been carried out in this direction, but one human subject was vaccinated, and the serological reactions after vaccination demonstrated the presence of immune bodies in the blood.

An eleven-day-old culture of a rodent leptospiral strain was heated for half an hour at 56° C. on two successive days, and 0.5 per cent. carbolic acid was then added. After several days in the cold room 0.1 c.cm. of this vaccine was inoculated subcutaneously, followed two days later by 2 c.cm. and after a further interval of seven days by 3 c.cm. No reactions, local or general, were observed after these injections.

When tested against the homologous leptospiral strain ten days after the last inoculation the serum of this vaccinated subject gave a positive Pfeiffer reaction. A negative reaction was obtained, however, on the forty-third day. Protective experiments showed that this serum was highly protective on the tenth day after vaccination. Agglutination tests carried out on the eleventh day showed definite agglutination in the dilution of 1 in 5, with lytic and degenerative changes in a dilution of 1 in 10. On the forty-seventh day slight agglutination was observed in a dilution of 1 in 4. No changes occurred in a 1 in 2 dilution of normal serum used as a control.

The serum of this subject had been used, prior to his being vaccinated, as a control in protection experiments, and in Pfeiffer and agglutination tests. It then gave negative results in these tests.

Some Fletcher's medium containing this subject's serum, obtained nineteen days after vaccination, in place of rabbit's serum, was inoculated with the homologous rodent strain and two human leptospiral strains. Three weeks later the same diffuse, lumpy, and granular appearance which was noted in the cultures containing convalescent serum was also manifested by these cultures, and microscopical examination showed marked agglutination of the leptospirae.

Epidemiological Aspects

For many years there have been outbreaks of unclassified fevers in the coastal areas of North Queensland. Investigation into these fevers has been conducted over many years by the Australian Institute of Tropical Medicine, and has resulted in the identification of: (1) a type of typhoid fever due to aberrant strain of typhoid bacillus (Cairns) in which the blood serum does not act positively in the Widal test as ordinarily performed with the Rawlings emulsion of typhoid bacilli; (2) a group of fevers due to infection by *Pseudomonas aeruginosa* (*B. pyocyaneus*); and (3) the occurrence of endemic typhus (Brill's disease). Other fevers have been found to be due to malaria, filariasis, and dengue, but the majority of these coastal fevers still await elucidation. Various terms have been applied to these fevers, such as "Mossman fever" and "Sarina fever" according to location, or more generally they have been termed "coastal fever."

On August 23rd, 1934, Weil's disease, and the undifferentiated fevers known as "coastal fever," "Mossman fever," and "Sarina fever," were declared to be notifiable diseases with respect to the whole of the State of Queensland.

In 1929 Dr. A. H. Baldwin of the Commonwealth Department of Health suggested that some cases of these coastal fevers might be due to leptospirosis, and the question of previous occurrence of Weil's disease in North Queensland is of great interest. Dr. Morrissey and Dr. Leckie, in their years of practice at Ingham, do not recollect seeing cases prior to the beginning of the outbreaks in 1933. A number of serological tests carried out on sera of persons who have suffered from "coastal fever" in recent years, including one case which developed jaundice, yielded negative results. An outbreak of "coastal fever" occurred at Tully, sixty miles north of Ingham, in June and July, 1934, when upwards of thirty people became infected within a few weeks. In this outbreak cane-cutters only, with the exception of a gang cook, were affected, although during the past few years cases have occurred among townspeople and workers in the scrub.

Similar weather conditions to those at Ingham prevailed at Tully, and it is believed by cane-cutters that when a spell of warm weather follows a wet spell an outbreak of "coastal fever" is apt to occur. Some patients had experienced four or five attacks of "fever" over a period of several cutting seasons. It is of some interest to record here that a cane-cutter who developed Weil's disease at Ingham in August, 1934, had had two attacks of coastal fever, one in 1928 and the other in 1930. Dr. R. Y. Mathew of the Commonwealth Health Laboratory, Cairns, carried out laboratory investigations in a number of cases, but the findings were negative as regards leptospirosis. Jaundice was not present in any of those examined, though it has been noticed in some previously seen. The symptomatology of these cases was similar to that of the mild forms of Weil's disease which occurred at Ingham. Convalescence was rapid and there were no deaths. Mathew[3] states: "There seems to be a possibility of the disease being a form of leptospirosis or atypical dengue, but laboratory tests so far have proved of value only in excluding other possibilities in regard to a more exact diagnosis than coastal fever.

In late September and October, 1934, a similar outbreak occurred among cane-cutters at Innisfail, ninety miles north of Ingham. Two patients developed jaundice and died. One developed jaundice on the seventh day and subconjunctival haemorrhages on the eighth day, and died on the tenth day. Jaundice in this case was slight, and no necropsy was performed. In both cases the clinical picture suggested Weil's disease. Laboratory tests did not confirm this diagnosis.

Recently, in March, 1935, at Babinda, about one hundred miles north of Ingham, an Italian farm labourer was admitted to hospital with the following history. He became ill two days previously with headache, fever, and pains in the legs. On admission his temperature was 101° F. A few rales were present in his chest, and his general condition was good. Epistaxis occurred on the fifth and sixth days, and blood appeared in the urine on the seventh day; about this time his condition became worse. His eyelids began to droop, jaundice appeared, and he complained of pain in the right upper abdomen. He vomited several times, but there was nothing distinctive in the vomitus. His liver was enlarged to three fingerbreadths below the costal margin, and was tender. The axillary lymph glands were not palpable. He became restless and confused, and died on the ninth day. A necropsy was performed by Dr. T. W. Carroll. There was a moderate degree of jaundice throughout the skin and body. Petechiae were absent, but small subperitoneal haemorrhages were present. There were numerous blotchy, haemorrhagic patches on the surface of the lungs. The liver was enlarged, and soft in consistency. The spleen was enlarged, soft, and pulpy, and showed a few haemorrhagic areas. The kidney was enlarged, and the cortex appeared to be swollen. A Pfeiffer test carried out with serum obtained on the eleventh day was positive, and the control guinea-pig died on the fifth day after inoculation of typical leptospirosis, while the other guinea-pig lived for twenty-four days, dying of peritonitis; there was no evidence of leptospirosis. A further Pfeiffer test carried out on serum obtained at the post-mortem examination was also positive.

During the past twelve months many cases of fever occurring in the Mossman and Cairns districts have been investigated by Dr. Mathew. None of these patients developed jaundice, and no deaths have occurred. Laboratory tests to date have been negative for Weil's disease, and in only a very few cases was a definite diagnosis such as typhoid fever, malaria, endemic typhus fever, and pyelitis established by laboratory tests.

Serological tests on sera of several cases clinically resembling Weil's disease, occurring in districts south of Townsville during the past six months, have invariably been negative.

In the Ingham district no cases of Weil's disease have been reported since October, 1934. Unusually dry weather has been experienced since then, and this is probably a very important factor in connexion with the cessation of these outbreaks.

In Australia, apart from the imported rats, there are about fifty species of native rodents in addition to small marsupials commonly known as "pouched rats" and "pouched mice," and the fact that in the Ingham district one of these native species of rodents, the *Rattus culmorum*, is the chief animal reservoir of leptospirae is of great interest in regard to the origin of this epidemic.

It is possible that pathogenic leptospirae may have been introduced by imported rats, and that the native species, possessing no immunity, became heavily infected over a comparatively short period. The other possibility is that these indigenous rodents have always been carriers, and that the great increase in rat infestation and the excessively heavy rainfall combined to bring about a situation favourable to the occurrence of an epidemic amongst workers in the cane fields.

Conclusion

The occurrence of Weil's disease in the sugar-cane areas of North Queensland is of serious import from both health and economic aspects. The favourable climatic conditions and the presence of infected rodents will almost certainly cause this disease to become endemic and con-

stitute a constant hazard to the health of the workers in the fields. Repeated poisoning campaigns and clearing of harbourage will be required to decrease rat infestation effectively, and the question of prophylactic vaccination is worthy of serious consideration. Laboratory investigations regarding various aspects of Weil's disease are being actively continued at the School of Public Health and Tropical Medicine, at the Commonwealth Serum Laboratories in Melbourne, and at the Commonwealth Health Laboratories in Cairns and Townsville.

I am indebted to Dr. H. J. L. Cumpston, Director-General of Health, Commonwealth Department of Health, for permission to present this paper; to Dr. F. McCallum, senior medical officer, Canberra, and to Dr. Paul Mitchell, Chief Quarantine Officer General, North-Eastern Division, Commonwealth Department of Health, for direction and facilities afforded in connexion with laboratory investigations; to Dr. G. C. Morrissey of Ingham for the clinical data regarding the epidemic; to Dr. W. C. Sawers of the School of Public Health and Tropical Medicine, University of Sydney, for epidemiological facts and laboratory findings; and to Dr. R. Y. Mathew, Commonwealth Health Laboratory, Cairns, for records of cases investigated in the Tully, Innisfail, and Cairns districts.

REFERENCES

1 Schuffner, W.: *Trans. Roy. Soc. Trop. Med. and Hyg.*, 1934, xxviii, No. 1, 20.
2 Fletcher, W.: Ibid., xxi, No. 4, 268.
3 Buchanan, G.: Medical Research Council, Special Report Series No. 113, p. 56.
4 Fletcher, W.: *Trans. Roy. Soc. Trop. Med. and Hyg.*, xxi, No. 4, 269.
5 Mathew, R. Y.: *Health*, the Journal of the Comonwealth Department of Health, 1934, xii, No. 8, 57.

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Diary of Central Meetings

JANUARY

31 Fri. Workmen's Compensation Subcommittee, 2 p.m.

FEBRUARY

4 Tues. Special Subcommittee of Naval and Military Committee, 2.30 p.m.
5 Wed. Physical Education Committee, Training of Teachers Subcommittee, 2 p.m.
Ophthalmic Committee, Central Clinics Subcommittee, 3 p.m.
6 Thurs. Dominions Executive Subcommittee, 2.15 p.m.
7 Fri. Science Committee, 2 p.m.
11 Tues. Standing Ethical Subcommittee, 2.30 p.m.
12 Wed. Physical Education Committee, 2 p.m.

MARCH

13 Fri. Public Health Committee, 2 p.m.
17 Tues. Organization Committee, 2.30 p.m.
20 Fri. Journal Committee, 2.30 p.m.

APRIL

8 Wed. **Council,** 10 a.m.

MAY

8 Fri. Public Health Committee, 2 p.m.

BRANCH AND DIVISION MEETINGS TO BE HELD

BATH, BRISTOL, AND SOMERSET BRANCH: WEST SOMERSET DIVISION.—At Glebeland, Chard, Tuesday, February 4th, 3.30 p.m. Dr. Charles Seward: "The Significance of Dyspepsia in and after Middle Age."

GLASGOW AND WEST OF SCOTLAND BRANCH: LANARKSHIRE DIVISION.—At Victoria Infirmary, Glasgow, Wednesday, February 5th, 3.30 p.m. Dr. Alex. Glen: "Glycosuria, its Significance."

HERTFORDSHIRE BRANCH: EAST HERTFORDSHIRE DIVISION.—At Cromwell Hotel, Stevenage, Thursday, February 6th, 8 p.m. Mr. Julian Taylor: "The Treatment of Toxic Goitre."

KENT BRANCH: BROMLEY DIVISION.—Joint meeting with Beckenham Medical Society at Railway Hotel, Beckenham, Thursday, February 6th. 7.45 p.m., supper; 8.45 p.m., Mr. Victor Lack: "The Use and Misuse of Forceps."

LANCASHIRE AND CHESHIRE BRANCH: PRESTON DIVISION.—At Overseers' Buildings, Lancaster Road, Preston, Friday, February 7th, 8.30 p.m. General meeting. Consideration of adoption of resolutions, etc.

METROPOLITAN COUNTIES BRANCH: CITY DIVISION.—At Metropolitan Hospital, Kingsland Road, E., Tuesday, February 4th, 9.30 p.m. Sir Crisp English: "Abdominal Problems."

METROPOLITAN COUNTIES BRANCH: MARYLEBONE DIVISION.—At B.M.A. House, Tavistock Square, W.C., Thursday, February 13th, 8.30 p.m. General meeting. Major H. Lockwood Stevens: Cinematograph film on Nepal.

METROPOLITAN COUNTIES BRANCH: NORTH MIDDLESEX DIVISION.—Wednesday, February 5th. Ten-minute papers.

METROPOLITAN COUNTIES BRANCH: ST. PANCRAS DIVISION.—At British Red Cross Society's Clinic for Rheumatism, Fitzroy Place, Marylebone Road, N.W., Tuesday, February 11th, 8.45 p.m. Consideration of adoption of resolution, followed by an address by Dr. Frank Howitt: "The Treatment of Rheumatism by Physiotherapy."

METROPOLITAN COUNTIES BRANCH: STRATFORD DIVISION.—At East Ham Memorial Hospital, Wednesday, February 5th, 3 p.m. Clinical meeting.

METROPOLITAN COUNTIES BRANCH: WOOLWICH DIVISION.—At Woolwich War Memorial Hospital, Tuesday, February 4th, 8.45 p.m. Clinical meeting.

NORTHERN IRELAND BRANCH.—At Whitla Medical Institute, College Square North, Belfast, Thursday, February 6th, 4.30 p.m. Mr. S. T. Irwin: "The Trip to Australia and Back with the British Medical Association."

NORTH OF ENGLAND BRANCH: GATESHEAD DIVISION.—At Liberal Club, Pilgrim Street, Newcastle-upon-Tyne, Tuesday, February 4th, 8.30 p.m. Address by Dr. D. Ramage.

SHROPSHIRE AND MID-WALES BRANCH.—At Royal Salop Infirmary, Shrewsbury, Tuesday, February 4th, 3.30 p.m. General meeting. Consideration of (*a*) adoption of resolution; (*b*) scale of fees of National Deposit Friendly Society; and (*c*) fees for reports on workmen's compensation and accident cases, etc. 3.45 p.m., Clinical meeting.

SOUTHERN BRANCH: PORTSMOUTH DIVISION.—At Queen's Hotel, Southsea, Thursday, February 13th. 9 p.m., supper; 9.30 p.m., Dr. John Freeman: "Asthma and Allied Diseases."

SOUTH WALES AND MONMOUTHSHIRE BRANCH: SWANSEA DIVISION.—Thursday, February 6th. Mr. W. Maclean: "Some Surgical Aspects of Haematuria."

SURREY BRANCH: CROYDON DIVISION.—At Croydon General Hospital, Tuesday, February 11th, 8.30 p.m. Consideration of adoption of resolution, followed by an address by Dr. Murdo Mackenzie: "The Anxiety Apathy Cycle."

SUSSEX BRANCH: WEST SUSSEX DIVISION.—At Royal West Sussex Hospital, Chichester, Friday, February 7th, 8.30 p.m. Dr. H. G. McGregor: "Human Heredity and Disease."

YORKSHIRE BRANCH: SCARBOROUGH DIVISION.—At Scarborough Hospital and Dispensary, Saturday, February 1st, 9.15 a.m. Demonstration.

YORKSHIRE BRANCH: WAKEFIELD, PONTEFRACT, AND CASTLEFORD DIVISION.—At Strafford Arms Hotel, Wakefield, Thursday, February 6th. Dr. H. G. Garland: "Recent Advances in the Investigation and Treatment of Nervous Diseases." Preceded by dinner at 7.45 p.m.

The Diary of Societies and Lectures and Post-Graduate Courses, together with the usual lists of Vacancies and Appointments, etc., will be found at pages 243 and 244 of the Journal.

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